

PROBLEM 3.7

A 400-N force **P** is applied at Point **A** of the bell crank shown. (a) Compute the moment of the force **P** about **O** by resolving it into components along line **OA** and in a direction perpendicular to that line. (b) Determine the magnitude and direction of the smallest force **Q** applied at **B** that has the same moment as **P** about **O**.

SOLUTION

(a) Portion *OA* of crank:

$$\theta = 90^\circ - 30^\circ - 40^\circ$$

$$\theta = 20^\circ$$

$$S = P \sin \theta$$

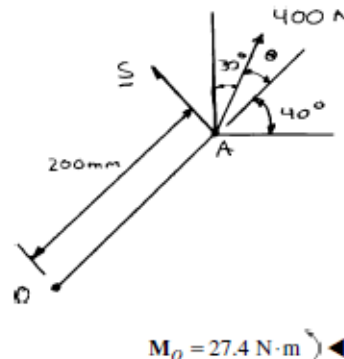
$$= (400 \text{ N}) \sin 20^\circ$$

$$= 136.81 \text{ N}$$

$$M_O = r_{OA} S$$

$$= (0.2 \text{ m})(136.81 \text{ N})$$

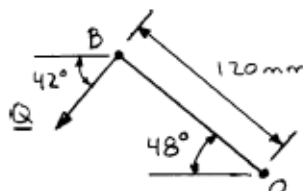
$$= 27.362 \text{ N}\cdot\text{m}$$



$M_O = 27.4 \text{ N}\cdot\text{m}$ ◀

(b) Smallest force **Q** must be perpendicular to *OB*.

Portion *OB* of crank:



$$M_O = r_{OB} Q$$

$$M_O = (0.120 \text{ m}) Q$$

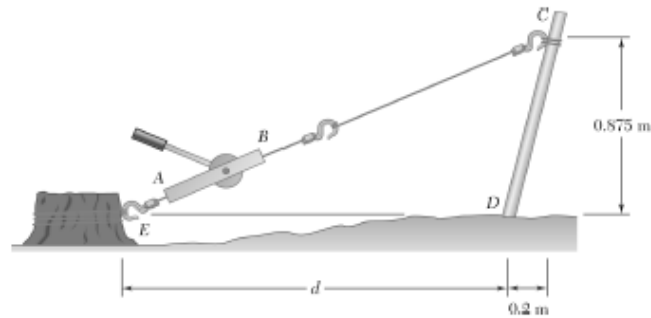
$$27.362 \text{ N}\cdot\text{m} = (0.120 \text{ m}) Q$$

$Q = 228 \text{ N} \nearrow 42.0^\circ$ ◀

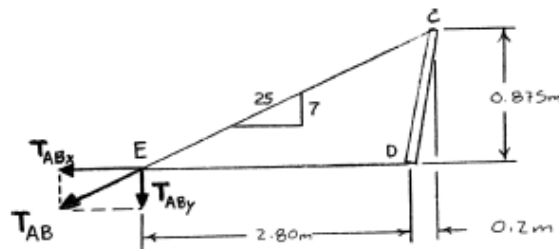
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PROBLEM 3.12

It is known that a force with a moment of 960 N · m about *D* is required to straighten the fence post *CD*. If $d = 2.80$ m, determine the tension that must be developed in the cable of winch puller *AB* to create the required moment about Point *D*.



SOLUTION



Slope of line:
$$EC = \frac{0.875 \text{ m}}{2.80 \text{ m} + 0.2 \text{ m}} = \frac{7}{24}$$

Then
$$T_{ABx} = \frac{24}{25} T_{AB}$$

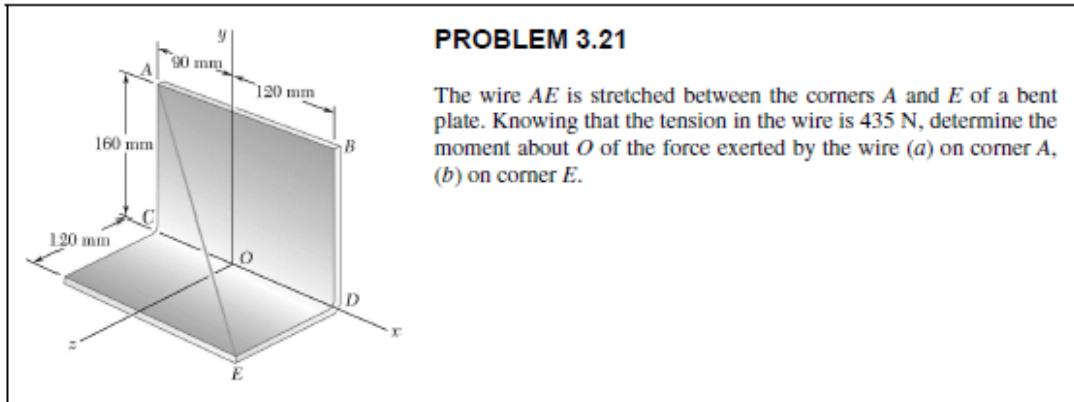
and
$$T_{ABy} = \frac{7}{25} T_{AB}$$

We have
$$M_D = T_{ABx}(y) + T_{ABy}(x)$$

$$960 \text{ N} \cdot \text{m} = \frac{24}{25} T_{AB}(0) + \frac{7}{25} T_{AB}(2.80 \text{ m})$$

$$T_{AB} = 1224 \text{ N} \quad \text{or } T_{AB} = 1224 \text{ N} \quad \blacktriangleleft$$

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SOLUTION

$$\overline{AE} = (0.21 \text{ m})\mathbf{i} - (0.16 \text{ m})\mathbf{j} + (0.12 \text{ m})\mathbf{k}$$

$$AE = \sqrt{(0.21 \text{ m})^2 + (-0.16 \text{ m})^2 + (0.12 \text{ m})^2} = 0.29 \text{ m}$$

(a) $\mathbf{F}_A = F_A \lambda_{AE} = F \frac{\overline{AE}}{AE}$

$$= (435 \text{ N}) \frac{0.21\mathbf{i} - 0.16\mathbf{j} + 0.12\mathbf{k}}{0.29}$$

$$= (315 \text{ N})\mathbf{i} - (240 \text{ N})\mathbf{j} + (180 \text{ N})\mathbf{k}$$

$$\mathbf{r}_{AO} = -(0.09 \text{ m})\mathbf{i} + (0.16 \text{ m})\mathbf{j}$$

$$\mathbf{M}_O = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -0.09 & 0.16 & 0 \\ 315 & -240 & 180 \end{vmatrix}$$

$$= 28.8\mathbf{i} + 16.20\mathbf{j} + (21.6 - 50.4)\mathbf{k}$$

$$\mathbf{M}_O = (28.8 \text{ N}\cdot\text{m})\mathbf{i} + (16.20 \text{ N}\cdot\text{m})\mathbf{j} - (28.8 \text{ N}\cdot\text{m})\mathbf{k} \quad \blacktriangleleft$$

(b) $\mathbf{F}_E = -\mathbf{F}_A = -(315 \text{ N})\mathbf{i} + (240 \text{ N})\mathbf{j} - (180 \text{ N})\mathbf{k}$

$$\mathbf{r}_{EO} = (0.12 \text{ m})\mathbf{i} + (0.12 \text{ m})\mathbf{k}$$

$$\mathbf{M}_O = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0.12 & 0 & 0.12 \\ -315 & 240 & -180 \end{vmatrix}$$

$$= -28.8\mathbf{i} + (-37.8 + 21.6)\mathbf{j} + 28.8\mathbf{k}$$

$$\mathbf{M}_O = -(28.8 \text{ N}\cdot\text{m})\mathbf{i} - (16.20 \text{ N}\cdot\text{m})\mathbf{j} + (28.8 \text{ N}\cdot\text{m})\mathbf{k} \quad \blacktriangleleft$$

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